UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. Bennett, Chief

GUIDE
FOR
SOIL CONSERVATION SURVEYS

For use within the Soil Conservation Service

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F O R E W O R D

This booklet is primarily for soil scientists in the Soil Conservation Service. It will be useful also to other professional people who use soil conservation survey maps. It contains a brief statement of the principles of soil conservation surveys, and presents a discussion of the major soil and land characteristics that are evaluated and mapped. This informational Guide is for use in setting up new survey legends; in checking, evaluating, and improving work already completed; and in making interpretations of land conditions in terms of land capabilities and treatments.

As a soil scientist in soil conservation operations, your duties are of a professional nature. You have acquired special training and skill, perhaps at no little personal expense. The Soil Conservation Service employs you to apply your knowledge and skill in a particular job -- the job of getting conservation on the land. The Service expects you to work on a professional level, to utilize fully your professional ability, and to direct your official efforts 100 percent toward the conservation job. Farmers count on you too.

Part of your professional job as a soil scientist consists of the identification and mapping of land conditions. Such a job is done for a specific, twofold purpose: (1) To furnish the farm planner with information about land and land capability that he needs in order to help the farmer plan good conservation; and (2) To furnish the farmer, an able man but one who may lack your professional background, with the facts about his land that he needs in order to plan and practice conservation.

No matter where you work as a soil scientist in the Service, your job includes professional duties in addition to making maps. You are expected to interpret land conditions for fellow technicians and for farmers. You have the job of writing or helping to write legends and explanations in plain language to accompany farm maps. You assist or lead in preparing land-capability tables and technical guides. You help the administrative officers see that land is used according to its capability and treated according to its needs. You are the professional soils man available to help solve problems as they arise; for example, to advise on pond

sites, drainage investigations, soil deficiencies, and other questions involving soils. You have reports to write. Part of your professional duty is to know when to call for help on difficult problems. If you are a survey supervisor or state soil scientist, your duties may consist largely of activities other than mapping. State soil scientists have particular responsibilities for cooperation with agricultural experiment stations and other agencies.

This Guide was prepared primarily by A. M. O'Neal, W. J. Latimer, and J. G. Steele. Careful consideration was given to the many valuable ideas and suggestions from regional and state soil scientists, survey supervisors, and many other soil scientists; and from a large number of technicians who use land information. Assistance from soil scientists in several of the State agricultural experiment stations is particularly acknowledged.

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GUIDE FOR SOIL CONSERVATION SURVEYS

Soil Conservation Surveys for Farm Planning

Soil conservation surveys are being made of those areas for which information is needed for soil conservation operations. *Soil conservation surveys will show only the variations in land that affect its use, management, and treatment.*

Land factors usually mapped include soil, slope, and degree of erosion. Certain other physical conditions as flood hazards, wetness, and salinity are also mapped where necessary. Land use at the time of the survey is also essential information for conservation planning and other purposes.

Land mapping units needed in soil conservation mapping are those characterized by differences that are significant in their relation to use capability and soil conservation requirements. Factors of soil, slope, and erosion are of most general significance.

Status of Mapping

Surveys adequate in scale and detail for farm planning had been made on about 270,000,000 acres on July 1, 1947. These surveys have been completed in approximately 300 areas. Some of these cover counties, but more than half of them are of smaller size, such as the soil conservation demonstration project areas of the 1933-1937 period and some of the earlier soil conservation districts. Since 1945 the conservation survey work has been almost entirely of the farm-planning type.[1]

Legends showing the various land-type classifications needed for those areas designated for survey have been established for more than 60 percent of the counties of the United States. Most of this work is done for farm-planning purposes. Some surveys, mostly those completed before 1945,

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[1]The Service participates in the work of the "basic soil surveys," which amounts to less than 3 percent of the total acreage covered by the soil conservation surveys.

differed in some respects from the later surveys.[2] The job of preparing land-classification designations (legends) for farm surveys is more than half done. Legends for remaining unsurveyed areas probably can be prepared in most States largely by utilizing the work already done.

Land-capability Classes[3]

Soil conservation surveys are primarily designed to furnish basic physical land information needed to guide farm planning for proper application of soil conservation practices. The soil conservation surveyor identifies and maps the significant land-type units of entire farms occurring within the conservation work area. After a sufficient number of representative farms are mapped, Service technicians study the land conditions found in the work area and develop from that information, together with local farmer experiences and data from research findings, a land-capability classification. Farmers and others having practical farm knowledge of the land of the locality are consulted in working out the capability classes.

The land-capability classes represent summarizations, for practical use, of the interpretations of the land facts ascertained and recorded by the soil conservation surveyor and other Service technicians, plus any available helpful information from farmer experience.

Farm-planning technicians use the land-capability maps to guide them in developing, cooperatively with the farmer, a scientific plan for the proper use and protection of all the land on the farm -- cropland, forest land, pasture land, idle land, gullies, etc. Their job, in other words, is to help farmers to use their land -- all of it -- according to its capability and to treat it according to need (parcel by parcel, where such distinct parcels are of important extent).

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[2] The later surveys, which are designed for use as a basis for conservation planning, show only the variations in land that affect its use, management, and treatment. That is, they show those land characteristics that significantly affect conservation practices, crop adaptation, crop yields, and management requirements.

[3] Land-capability classes are described in:

Bennett, H. H. *Our American Land,* USDA Misc. Pub. 596.

Hockensmith, R. D., and Steele, J. G. *Classifying Land for Conservation Farming,* USDA Farmers' Bulletin 1853.

Hockensmith, R. D. *The Scientific Basis for Conservation Farming,* Journal of Soil and Water Conservation, January 1947, pp. 9-16.

The Soil Conservation Service also derives from these land studies certain statistical information needed in making plans for immediate and long-time operations over large land areas.

Uses of This Guide

This Guide for making soil conservation surveys deals primarily with the recognition, selection, designation, and description of significant land mapping units. It does not take up, except in a very brief way, the principles or methods of determining and classifying land capability. A short statement with respect to principles underlying soil conservation surveys for farm planning is given, and a system for uniform terminology for identifying and describing most of the essential features of land mapping units is also included.

In certain areas, some of the factors do not have significance in farm conservation planning and should be omitted from local legends. This Guide is primarily for use by (a) Service technicians responsible for developing, reviewing, and approving survey legends, and (b) those who prepare descriptions of the physical conditions of land.

The purposes of the Guide are:

1. To list the principal characteristics of land that are known to have significance in farm planning; to define the ranges in the characteristics that have been found to be significant in the use, management, and protection of the land; and to list certain indications by which significant ranges of each significant characteristic can be ascertained;

2. To establish a uniform nomenclature for the land characteristics and for the significant ranges of each characteristic;

3. To suggest methods by which significant characteristics of land and their ranges are to be utilized in developing legends for guiding mapping operations. This includes:

    a. Determination of the mapping units needed;

    b. Definitions of the mapping units, using established terminology; and

    c. Determination of descriptive terms most useful locally in identifying and describing significant land conditions.

Names and descriptive terms used in this Guide are as nearly complete and exact as they can be made with available information. As soil technicians develop individual legends, sometimes they may find somewhat more precisely adaptable terms or more nearly accurate or fuller descriptions of some of the factors. Uniform national terminology, precise and adequate as to technical facts and needs, is essential. In addition to the national terminology, special local terms may sometimes be needed, but they are to be used sparingly.

National uniformity in the principles of establishing land mapping units is essential, of course, for the most advantageous utilization of the information accumulated. There must, however, be some slight flexibility in the application of the basic principles in order to take care of local needs. Some of the regions already have set up definite and more or less region-wide systems of symbols, others have not. It should not be overlooked that excessive variations from region to region could easily become confusing. There must be the greatest possible uniformity throughout. Where the regions prepare guides, they must be developed within the framework of the national Guide and submitted to the Washington office for review and coordination. The names designating the ranges of each soil characteristic given in the national Guide should be used.

Interpretation of Old Surveys

The criteria, principles of procedures, and descriptive terms in this Guide are for use in making correct interpretations of the older surveys, as well as for setting up new legends. In setting up a new legend, one of the main objectives is to establish significant limits with respect to the mapping units. In making use of older surveys, the main problem is to classify the older mapping units into significant land-treatment units. When experience shows that the older mapping units were not properly selected, field checks may be necessary. Land-treatment units are grouped into the land-capability classes. The terminology given in this Guide permits uniformity in descriptions of land-treatment units in different areas.

Soil Mapping Units

Soil mapping units are separated from each other according to mappable differences in the soil characteristics known to be significant in farm conservation planning. Some of these characteristics can be observed directly, others may be inferred from observable indicators.

Ordinarily the most significant soil characteristics are: Effective depth of soil, texture of surface soil, and permeability of subsoil. Other significant characteristics may be thickness of particular surface soil or subsoil layers, permeability of substratum, character of underlying material, available moisture capacity, natural soil drainage (indicated usually by the profile coloring, especially mottling), degree of acidity or alkalinity, amount of organic matter, or deficiencies in plant nutrients.

Effective Depth of Soil

Effective Depth of Soil refers to the depth of soil material which plant roots can penetrate readily in search of water and plant nutrients. It is the depth or layer of soil most favorable for growth of roots and for storage of plant-usable moisture, above a layer that differs from the overlying material in physical or chemical properties sufficiently to prevent or seriously retard the growth of roots. The character of any distinctive material limiting effective depth should be part of the designation. For example, a soil may be described as shallow over rock, hardpan, claypan, caliche, gravel, or other distinctive material affecting root penetrability and moisture status in the overlying material. This conservation aspect of depth connotes something different from just a profile layer involved with soil type classification. It carries a utilitarian meaning -- a relationship to such matters as drainage, ease of cultivation, resistance to erosion, available moisture capacity, and volume of available soil material for good plant-root development. Effective depth of soil should not be confused with such measurements as thickness of surface soil, or depth to water table.

If the layer that limits effective depth of soil is rock or other hard material, the effective depth is also the practical limit of excavation. Other soils, such as those in which the limiting layer is claypan, gravel, etc., can be excavated without difficulty below the effective depth. The operational depth suitable for excavation should be described and mapped if the information is needed for any purpose, such as building a dam or leveling land for irrigation.

A shallow soil has limited capacity for retention of water and nutrients in the main feeding zone of plant roots. Generally speaking, crops suffer from lack of water more quickly on a shallow soil than they do on a deep soil. With shallow soils, leveling of land for irrigation may be limited or wholly impracticable. On slopes the choice of terracing methods may depend on depth of soil as well as on whether or not the gradient is too steep for terracing. This is only a partial list of the situations in which effective depth affects farm conservation planning.

The following are the depth ranges and descriptive terms that have been found useful in delimiting effective depth of the root zone:

Deep	36 inches or more
Moderately deep. . .	20 to 36 inches
Shallow	10 to 20 inches
Very shallow	Less than 10 inches

Some reasonable variation from these normal limits may be needed to meet local requirements. In some localities it may be necessary to separate (1) soils without layers obstructive to root growth at any depth, or at some depth below 60 inches, from (2) those soils with inhibiting layers at depths of 36 to 60 inches. In such cases the term <u>very deep</u> could be used for the 60-inch or deeper range, and the term <u>deep</u> for the 36 to 60-inch range.

The number of classes, with the depth limits for each, should be clearly stated in the legend.

In some areas additional information may be needed with respect to layers within the effective depth of soil, such as (1) thickness of the surface soil, (2) thickness of subsoil, or (3) thickness of sandy soil over a layer of much less permeability. Such expressions would be in addition to the effective depth of soil as it is defined here. If such information for surface and subsoil thickness is needed, the following terms will probably fit most conditions:

Thin	0 to 6 inches
Moderately thick . . .	6 to 12 "
Thick	12 to 18 "
Very thick	18 to 36 "

The terms <u>thick</u> and <u>thin</u> with appropriate prefixes are to be used in describing soil layers other than effective depth. <u>Deep</u> and <u>shallow</u> are terms to be reserved for expressing effective depth. For example, say thin surface soil, not shallow surface soil.

Texture of Surface Soil

Texture of Surface Soil is a characteristic closely associated with workability. It also influences erodibility, permeability, and other soil characteristics. The 15 or more recognized textural classes may be grouped into 7 or even fewer textural groups for purposes of farm planning for soil conservation. Such simplification of the textural range has been found adequate for sound conservation purposes. Moreover, it is much better understood by farmers.

The following terms and groupings are suggested. Both may need to be adapted to local needs. Each legend should show the recognized textural classes that make up each textural group used in mapping.

Textural groupings for farm planning for soil conservation

Suggested textural term	Alternate terms	Suggested textural classes to be included
Very heavy	Very fine textured--heavy clays--very clayey	Heavy clay, 60% or more 2-micron clay
Heavy	Fine textured-clays--clayey	Clay, silty clay, sandy clay
Moderately heavy	Moderately fine textured--clay loams--moderately clayey	Silty clay loam, clay loam, sandy clay loam
Medium	Loams--loamy	Silt loam, loam, very fine sandy loam
Moderately light	Moderately coarse--sandy loams--moderately sandy	Fine sandy loam, sandy loam
Light	Coarse--loamy sands--sandy	Loamy fine sand, loamy sand
Very light	Very coarse--sands--very sandy	Sand, coarse sand

Modifying terms may be needed to indicate rock fragments or outcrops. Those most often needed are gravelly, very gravelly, stony, very stony, and ledgy.

In some sections of the country a somewhat broader grouping of the textural classes, or some moderate shifting

in the classes listed, may be desirable. For instance, very fine sandy loam may be more appropriately classified as moderately light textured, rather than medium textured, insofar as planning needs are concerned. In some places there may be no need to differentiate the very heavy and heavy soils, or the light- and very light-textured soils. In some areas a textural grouping of heavy-, medium-, and light-textured soils may be sufficient. Also, in some parts of the country, especially in trucking areas, somewhat finer break-downs may be needed. For example, sandy loams may (but probably not often) require different treatment from fine sandy loams because of slight differences in crop response. Ecologically, as well as in respect to erosion potential, well-drained sandy loams and fine sandy loams are very closely related where subsoil conditions are similar.

The exact textural classes included in each textural group set up for mapping purposes must be shown clearly in the legend.

Permeability

In simplest terms, *soil permeability* may be defined as the capacity of a soil to transmit water or air. It can be expressed quantitatively in terms of rate of flow of water through a unit cross section of saturated soil in unit time under specified hydraulic conditions.

For mapping purposes it is necessary to determine the permeability of each horizon within the effective depth of soil, and also in most instances the permeability of the layer that fixes the lower limit of the effective depth. For comparing or estimating permeability of soils under field conditions, it is necessary to consider the permeability of all significant soil horizons and their relation to each other and to the entire profile. Often, however, chief concern is with the one or two least permeable horizons.

Permeability of the surface layer of soil affects the rate of infiltration to a very important degree. In a practical way, permeability of the first inch or two of soil under ideal cover and structural conditions fixes the maximum rate of infiltration. Infiltration during any particular storm or artificial test may approach this maximum rate, or, on the other hand, it may be near zero, depending on surface conditions, such as compaction, tendency to seal, and rate of percolation in the deeper horizons when the soil is saturated. Because of the wide variations, rate of infiltration is not considered directly in setting up soil mapping

units. It usually can be inferred, however, from the mappable soil characteristics when the cover and surface conditions are known.

The significant internal permeability of most soils can be described fairly well by stating the permeability of the subsoil and of the substratum. These two expressions, together with surface texture and a knowledge of surface conditions, give some idea of the approximate permeability of the soil. For specific purposes, however, such as the development of a drainage plan, measurements of permeability by horizons may be required.

As far as hydrological and soil studies have gone, seven degrees of permeability will express the most significant variations of this factor in agricultural soils. These ranges of permeability are:

Description of rate of permeability	Percolation in inches per hour through saturated undisturbed cores under 1/2-inch head of water[4]
Very slow	Less than .05
Slow	0.05 to 0.20
Moderately slow	0.20 to 0.80
Moderate	0.80 to 2.50
Moderately rapid	2.50 to 5.00
Rapid	5.00 to 10.00
Very rapid	More than 10.00

These seven ranges of permeability may be more than are needed in some areas, or be more than can be estimated from field indications. If three degrees of permeability should prove to be enough, the descriptions <u>slow</u>, <u>moderate</u>, and <u>rapid</u> would be sufficient. Wherever permeability measurements are available as a basis for estimates, the significance of each description used should be stated in terms of the percolation rate.

Some useful indications for estimating permeability in the North Central States under field conditions are given in the appendix. They have been tested by examining soils on which percolation tests have been made. Field studies in other parts of the country may reveal that permeability estimates should be based on a different set of indicators.

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[4]These ranges may need some revision as further studies are made.

Available Moisture Capacity

Available moisture capacity of a soil is its capacity to store water that is usable for plant growth. For most practical purposes, it is the difference between *moisture equivalent* and *wilting coefficient*.[5] Whenever there are two or more soil layers within the effective depth, the total available moisture capacity of the soil is the sum of the available moisture capacities of the different layers. The total available moisture capacity of the effective depth of soil is a measure of drought resistance.

When moisture equivalent and wilting coefficient are expressed in the usual way, as percentages of oven-dry soil, available water may be calculated if the volume weight and thickness of the horizon are known:

$$\text{Inches of available water} = \frac{(Pm - Pw) \times V \times D}{100}$$

where

Pm = *moisture equivalent*
Pw = *wilting coefficient*
V = *apparent specific gravity (volume weight)*
D = *thickness of soil horizon in inches*

The following terms and ranges are suggested for five degrees of available moisture capacity:

Degree of available moisture capacity	Available moisture capacity in inches of water per 60 inches of soil depth
Very high	12 inches or more
High	9 to 12 inches
Moderately high	6 to 9 "
Low	3 to 6 "
Very low	Less than 3 inches

In making field estimates of available moisture capacity of soils, considerable assistance can be derived from certain visible indicators that can be checked by the feel of the material. Texture and organic content are probably the most

[5]The moisture equivalent is the percentage of water held after subjecting a sample of wet soil held in a vessel of specified dimensions, to a centrifugal force of 1000 times gravity, equivalent to a pF value of approximately 2.7. The wilting coefficient is the percentage of water present in a soil when plants permanently wilt. This occurs at about pF 4.2. These values and the energy relations of soil water are discussed in any standard textbook on soils; for example, in *The Nature and Properties of Soils*, Lyon and Buckman, 1943, chapters 7 and 8.

important of these distinguishing characteristics. Silt loams, for example, hold more available water per foot than sandy loams; loamy sands hold less than fine sandy loams. Other characteristics, such as structure and consistence, may also prove useful indicators. Occasional laboratory checks may be desirable to insure uniformity of results. Also there may sometimes be local need for further division of the range limits shown. The numerical values for the different degrees of available moisture capacity may need some adjustment as more data are collected.

Reaction

Degree of acidity or alkalinity (pH range) occasionally is helpful in separating soil mapping units for soil conservation surveys for farm planning, especially in relation to the use of lime and sulphur. The following pH ranges have been found helpful:

Acid	Less than pH 6.5
Neutral	pH 6.6 to 7.3
Alkaline	pH 7.4 or more

Conservation planning needs may demand a somewhat narrower pH range for some parts of the country. It may even be necessary to give the reaction of different parts of the profile -- topsoil, subsoil, and substratum. Where finer separations are needed, it is suggested that the acid group be broken down into very strongly acid (pH 5.0 or less), strongly acid (pH 5.1 to 5.5), medium acid (pH 5.6 to 6.0), and slightly acid (pH 6.1 to 6.5). The ranges of alkalinity could be: Moderately alkaline (pH 7.4 to 8.5), strongly alkaline (pH 8.6 to 9.2), and very strongly alkaline (pH 9.3 or more). All ranges used should be clearly shown on the legend.

It may be important, in some cases, to know if any part of the soil profile contains enough free lime to effervesce with hydrochloric acid.

Natural Soil Drainage

Mottling, especially mixtures of grayish, pale yellowish, and rust-brown in the soil profile are common indicators of restricted or poor aeration caused by presence of excess water. Brighter yellowish or reddish colors and absence, or near absence, of mottling indicate much better aeration and drainage. The following profile drainage characteristics are recognized:

Well drained.--Soil is well oxidized and free from mottling in both the topsoil and subsoil. The underlying material may be slightly mottled or splotched.

Moderately well drained.--Soil is well oxidized and free from any mottling in the topsoil and upper part of the subsoil. Some slight mottling of grayish and rust-brown colors may characterize the lower part of the subsoil.

Imperfectly drained (or somewhat poorly drained).--Soil is well oxidized and free from mottling in the surface. The subsoil is mottled with grayish and shades of yellowish-brown and rust-brown colors. The intensity of mottling is usually greater than in the lower part of the subsoil of moderately well drained soils.

Poorly drained.--Soil is mottled grayish brown and brownish or is more or less solidly gray at or near the surface and often has light grayish layers just above the subsoil. The mottling is usually highly contrasted with yellowish, grayish, and rust-brown colors predominating. Small ferruginous concretions or accretions may occur on the surface and throughout the surface soil.

Very poorly drained.--Soil with dark-colored surface layer and gray or grayish and rust-brown mottled subsoil. Characteristically occurs in flat or slightly depressed situations where water normally stands or formerly stood for long periods at or near the surface (before drainage operations). Also included are those soils which have developed in places where water covered the surface all or most of the time. May have some rust-brown or grayish mottling at various depths through the profile. Peat and muck occur in such places where the conditions favor accumulation of plant remains.

Inherent Fertility

Inherent fertility is an important factor in the selection of soil mapping units, wherever the differences have significant relation to proper land use, management, and protection. Such characteristics may be of a sufficiently permanent nature to be mappable within at least helpful limits. Local differences in the mapping units with respect to fertility or lime requirements may need to be determined from soil tests.

Inherent fertility or nutrient level is difficult to evaluate on any national scale except with a very large number of fertility ratings. It is not necessary, however, to compare inherent fertility of soils in different regions. For these and other reasons, this factor generally should be used as a mapping criterion only when it is necessary to

separate mapping units that are alike in other characteristics. And it will not always be necessary to use the fertility factor even under these conditions, especially since it is not always easy to make safe evaluations of the fertility level.

Usually four degrees of inherent fertility -- high, moderate, low, and very low -- will be sufficient.

Organic Content

The *organic content* of a soil commonly is a fair index to its durability and productive capacity. Often it can be at least roughly determined on the basis of observable characteristics, especially color and sponginess. Organic-matter needs frequently can be roughly determined from the tendency of soils to crust or "bake," and within limits, other fertility needs can frequently be roughly appraised from local crop yields. Organic content, like inherent fertility, generally should be used only to differentiate mapping units that otherwise are similar.

The following broad classes will commonly suffice: High, medium, and low.

Underlying or Parent Material

Character of *underlying or parent material* is often an indicator that is significant in setting up mapping units for soil conservation surveys needed for farm planning. Soils developed on calcareous glacial drift may be more desirable for the production of some crops than those developed on acid glacial material. Soils of limestone origin usually are more productive than those derived from such material as noncalcareous sandstone, acid shale, or granitic rocks. Parent material may give some indication of outstanding soil deficiencies, such as lack of copper or manganese and the presence of toxic elements such as selenium.

Organic Soils

Properties of *organic soils* most likely to be significant in setting up mapping units are:

1. Thickness of organic material;

2. Kind and thickness of underlying material, and especially its permeability;

3. Reaction (pH range);

4. Texture or structure of the surface layer: Peat or muck. If muck, an estimate of the amount of mineral matter will be helpful; and

5. Character or composition of organic material, such as sphagnum peat, sawgrass peat.

Use of the term shallow should be avoided unless the characteristics of the profile add up to the equivalent of a shallow soil. For example, 18 inches of peat over sandy clay may have the crop-response value of a deep soil; on the other hand 18 inches of peat over limestone may, for the same or other reasons, be properly described as shallow. The standards of thickness of surface layers given on *page 6* for mineral soils will need to be modified for organic soils.

If organic soils are covered with an overwash of mineral soil, the necessary significant mapping units should be determined, described, and given descriptive titles.

Other Characteristics

Soil characteristics other than those enumerated may be found significant in land use and management. They should be considered, of course, in setting up soil mapping units.

Names and Descriptive Titles for Soil Units

After the soil mapping units are determined, suitable names or descriptive titles should be prepared. The important soil types occurring in each mapping unit within a given survey area should be listed where the information is available.

Table of Soil Characteristics

A table of significant soil characteristics will be found helpful in selecting soil mapping units for a new survey; in appraising the significance of soil units shown on a completed or partly completed survey; and in writing clear descriptions of soil mapping units or groups. *Table 6, pp. 38 and 39,* shows the important characteristics of several representative soil mapping units. A complete descriptive table similar to *Table 6* will be prepared in each district or survey area, and may constitute the legend for that area.

Associated Land Features

Associated land features such as slope, erosion, wetness, salinity, overflow hazard, and susceptibility to stream-bank cutting are significant in farm conservation plans. There may be still other features that can be classified and mapped.

Slope

Steepness of slope affects velocity of runoff, rate of erosion, use of farm machinery, and various other pertinent matters of land management and protection. It is, therefore, a land characteristic of great significance in the selection and application of soil conservation practices.

Significant ranges of slope are determined on the basis of the best information available. If the soils, climate, and significant land use factors are fairly uniform, one group of slope classes may be enough. In some areas two or possibly three groups may be needed. For example, one group of slope classes might apply to moderately and rapidly permeable soils, and another, with more narrow limits for some of the classes, to slowly permeable and claypan soils. A second or third group of slope classes is to be set up only if there is a real need for it in relation to soil management and conservation. If more than one group of slope classes is established, the group that applies to each soil unit is to be indicated clearly. The limits of each slope class are to be determined and recorded at the time the first legend is prepared.

The following descriptive terms are suggested for designating the different slope classes: Nearly level, gently sloping, moderately sloping, strongly sloping, steep, and very steep.

Character of slope such as length, direction of exposure (north slope, south slope, etc.), and smoothness, may affect farm conservation plans, and in some instances it can be mapped. Undulating slopes in an irrigated area call for special treatment. Irregular slopes, such as the kame-and-kettle topography (small hillocks or ridges and depressions) of glacial areas, and karst topography (sinkhole) of limestone areas, may be worth a special mapping symbol.

Length of slope is significant in most conservation plans, although usually it is not represented directly by mapping symbols. If the length of slope is more or less characteristic of an area or a group of soils, it is given at least indirect consideration in setting up land-capability tables and recommendations.

Direction of slope affects the energy received from sunlight, with resulting variations in temperature and evaporation. Usually such variations are reflected in soil differences if they are great enough to affect land capability or recommendations for management of vegetation. Consideration should be given to mapping the direction of slope if it will add significant land information not otherwise shown.

Erosion

Erosion is the movement of soil and geologic material by natural agencies, primarily wind, water, and gravitational creep. Normal erosion is that not affected by human activity. Erosion mapping in soil conservation surveys for farm planning is almost entirely concerned with accelerated, or man-induced erosion (or soil erosion).

Erosion consists of two distinct processes: Detachment and transportation. Raindrops that fall on unprotected soil or in shallow water supply energy for the process of detachment. Flowing water is the transporting agent that completes the process of water erosion. Also, both wind and flowing water may detach and transport soil particles. If detachment occurs without transportation, there is no erosion.

The purpose of soil erosion mapping is twofold: (1) To give a quantitative estimate of the changes that have occurred and (2) to give an indication of the rate of past and possible future damage. Also it shows what is left in the way of productive topsoil.

Erosion classes are given in *Soil Conservation Survey Handbook*, USDA Miscellaneous Publication No. 352. In making surveys for farm-planning purposes, erosion classes can be frequently generalized somewhat from those given in the Survey Handbook. Whenever this is done, an erosion legend is to be set up and each class is to be defined. Symbols denoting the generalized classes should be standard erosion symbols from the Handbook. The number of erosion mapping units should be enough to show differences significant in the land-capability classification. The following grouping of detailed water and wind erosion classes into mapping separations should be used where adequate:

No apparent or slight erosion.--Less than 25 percent of the topsoil removed. Usually includes detailed erosion classes 0, +, 1, 17, P. No apparent erosion (0 and +) may be separated from slight erosion where this information is needed.

Moderate erosion.--25 to 75 percent of the topsoil removed; occasional gullies may be present. Usually includes erosion classes 1⑦, 2, 27, 2⑦, 17V, 27V, R.

Severe erosion.--75 percent or more of the topsoil or all topsoil and less than 25 percent of subsoil removed; occasional deep gullies or frequent shallow gullies may be present. Usually includes erosion classes 28, 3, 37, 3⑦, 37V, S.

Very severe erosion.--All of the topsoil and 25 to 75 percent of subsoil removed. Usually includes erosion classes 38, 4, 48, 5, T.

Very severely gullied land.--An intricate network of very frequent deep gullies. Usually includes erosion classes 3⑧, 38V, 4⑧, 48V, 9.

In some areas of range land it may be desirable to map 0 erosion as meaning not more than 25 percent (areally) of the surface litter removed.

Special Factors

Information on factors such as *wetness*, *salinity*, and *frequency of overflow*, may be needed for planning conservation work on farms. These special factors are sometimes called site factors. Some of them may be useful only in local areas, others may have wider application.

Wetness.--Too much free water within the effective depth of soil during the growing season interferes with growth of crops. Wetness, or presence of free water that persists long enough to be a significant land factor, may often be corrected by artificial drainage. To determine drainage needs, degree of wetness is considered in relation to the requirements of the crop and of the cropping system.

Degree of wetness in some instances is a useful land factor that can be classified and mapped. It may be the result of a high permanent water table, suspended or temporary water table, seepage from higher areas, level areas from which water moves off slowly, or heavy soils with slow underdrainage. If any of these conditions prevail for any length of time, usually they either leave their imprint on the soil profile or can be detected by the kind of vegetation present.

Degree of wetness cannot be used as an indicator of permeability. A soil may be wet, regardless of its permeability, if it contains ground water held there by a deeper slowly permeable or impermeable layer or barrier. Both

degree of wetness and permeability must be known for adequate planning and utilization of planning.

Soil color profiles described on *pages 11 and 12* indicate the natural degree of wetness that existed before artificial drainage. Wherever artificial drainage has been installed, the present degree of wetness is, because of the removal of excess water by drainage, less than that indicated by the color profile. In sections where the color profile is not a satisfactory indicator, degree of wetness is determined from other observations, especially the depth and fluctuation of water table, presence of salt crusts, and type and condition of vegetation.

Experience indicates that four degrees of wetness will meet most farm planning needs. These are:

Slightly wet:	Growth of crops may be slightly affected or the planting dates delayed for brief periods.
Moderately wet:	Growth of crops may be moderately affected or planting dates delayed by a week or so.
Very wet:	Growth of crops seriously affected, or planting delayed as much as a month or more; may be usable for improved pasture.
Extremely wet:	A swamp or marsh too wet for cultivated crops or improved pasture. Usable only for wildlife or such trees as cypress, tupelo, sweetgum, swamp oak, or swamp maple.

Definitions must be sufficiently specific to meet the needs of local areas. Physical feasibility of drainage should be indicated if it can be determined.

Salinity.--Presence of water-soluble salts in amounts toxic to commercial plants is frequently a serious limiting factor in land use. At least three separations will be needed in a good many irrigated areas. The following separations will ordinarily be sufficient:

Slight salinity:	Crop yields are slightly affected, or range in adaptable crops slightly limited.
Moderate salinity:	Crop yields moderately affected, or range in adaptable crops moderately limited.

Severe salinity:	Crop yields seriously affected, or range in adaptable crops severely limited.
Very severe salinity:	Satisfactory growth of useful vegetation impossible, except possibly for some of the most salt-tolerant forms, such as some of the Atriplexes having some use for grazing.

The definitions given may be sharpened for local areas, with more precise statements as to yields and cropping conditions. The physical feasibility of correcting or improving saline (alkaline) soils should be given, if known, as by drainage and flooding.

Frequency of overflow.--Overflow hazards often influence the use and management of land. For adequate land-capability classification it is necessary to know something about the frequency and duration of overflows to be expected. Specific standards for the separations must be established to fit local needs. Below are listed three broad standards that will meet most common needs:

Occasional overflows or overflows of short duration:	Crops occasionally damaged or planting dates somewhat delayed.
Frequent damaging overflows or overflows of long duration:	Crops frequently damaged or range of adaptable crops limited.
Very frequent damaging overflows or overflows of very long duration:	Not feasible for growing cultivated crops.

These classes may need to be defined more precisely to cover local conditions. The time of flooding may also be indicated.

Other factors.--Bottom lands subject to stream-bank cutting may need to be indicated and identified. Occasionally the topographic position will have significance enough to warrant separate expression. Character of the substratum usually can be covered in the characterization of soil mapping units. A separate symbol may be desirable in some legends.

Mapping Present Land Use

Present land use (or land cover in the case of land not used for crops) is needed for farm conservation planning and for other purposes. Each legend should provide for the following main classes of land use, or for as many of them as are present: Cropland (L); idle land (X); pasture or grazing land, or grassland (P); woodland (F); and possibly brushland. Still others may be set up if needed, but each class used is to be clearly defined always.

Appendix

The appendix contains a list of those soil characteristics found to be useful field indicators of permeability in the North Central States; a summary of the terms used in describing soil structure (with charts and a table) and soil consistence; a system of coding soil characteristics for easy reference with two tables; two tables that give in convenient form the descriptive terms used in this Guide for soil and land characteristics; and one table that gives descriptions of several soil mapping units.

Appendix

Indicators of Soil Permeability

Soil characteristics significant in estimating permeability in the North Central States are given below. Similar lists for other regions are to be assembled as the necessary studies are made, and are to be used as guides in estimation of soil permeability from observations in the field.

Very slow permeability.--Permeability at this rate is usually met with where claypans, hardpans, heavy clays, or relatively very slowly pervious sub-layers are present. Such soils crack badly on drying. The hardpan and indurated layers, however, do not crack or fracture. The structure, in the main, is either massive or *irregular angular blocky*. Often the material assumes a *columnar* structure. Soils with massive structure are generally mottled and free of visible pores. Where the irregular angular blocky type of structure dominates, the irregular fragments are very firmly developed. They have longer horizontal axes than vertical, have very sharp angles, and are meshed shingle-fashion with approximately a 50-percent horizontal overlap. Under some conditions where the moisture content is just right, the medium to coarse irregular angular blocks break further along definite cleavage faces to fine irregular angular blocky structure. The arrangement of the irregular angular blocks remains the same regardless of size. More force is required to break the blocks vertically than horizontally. Horizontal breakage is usually along the block faces, and in some instances the small irregular angular blocks can be flaked off horizontally. Some tortuous vertical channels that seem to follow block faces are discernible. These usually occur at 1 and 2-inch intervals and seldom extend more than 2 or 3 inches without a horizontal jog. The individual blocks have no visible pores. A high degree of mottling is an indication of this structural class.

The hardpan layers, sometimes associated with this class, often consist of highly indurated layers of sand or sand and gravel. When these horizons are struck with a spade, they usually give out a ringing sound. It usually is difficult to break into the mass, but once broken the small indurated lumps pulverize easily.

Slow permeability.--Permeability at this rate is usually associated with claypans, moderately indurated layers, clay, or silty clay layers, and "siltpans". Shrinkage is not so noticeable as in the very slowly permeable class and cracking is not so pronounced. The structure usually is fine to medium irregular angular blocky, except for siltpans. The irregular angular blocks have sharp angles and the horizontal axes are longer than the vertical. In general the blocks are meshed shingle-fashion with an approximate 40-percent horizontal overlap. More force is required to break the blocks along vertical axes. The broken faces tend to assume a saw-toothed appearance. The vertical cracks, which follow the block faces, seldom extend more than a very few inches before horizontal jogs of 1 or 2 inches appear. A few very small pores are discernible.

In the siltpan layers, horizontal bedding can easily be detected. Plates broken horizontally fracture along smooth, straight lines, and the laminated layers seem to be made up of many small flattish "chips" that can be easily lifted off with tweezers. These "chips" generally are laid down shingle-fashion with a horizontal overlap of 40 to 50

percent or more. Sometimes the thin laminated layers are continuous. Apparently flow of water follows tortuous lines around the many "chips". Only a few very fine vertical pores are visible. Grayish colors and mottling are indications of this type of structure.

Moderately slow permeability.--In general this class of permeability is associated with moderately heavy textured layers, layers showing a small amount of granulation, or layers showing slight dispersion of the particles. Shrinkage is usually not very pronounced, and cracks are not large or numerous. The structure, in general, takes the form of medium to fine irregular angular blocky fragments. These are not so firm and stable as those characterized by the very slowly and slowly permeable classes. Neither are the angles so sharp. They are often slightly rounded. Difference between the length of the horizontal and vertical axes is not so great as for the slower permeability rates. The fragments (clods) break more easily along vertical axes. The structural fragments usually overlap horizontally 20 to 25 percent. Occasionally the size, shape, and overlap of the fragments indicate slow permeability, but under such conditions the overlap is oblique rather than horizontal. This oblique type of overlap seems to be an indicator of a somewhat freer movement of air and water since the color is brighter and the mottling less than in the slow class. Pores are larger and more numerous than in the slow class. Also root penetration is greater.

Moderate permeability.--Usually this rate of permeability is associated with moderately heavy textures, slightly plastic when wet and moderately hard when dry. In general the structure is *fine to medium nuciform* (nutlike, partially rounded, some obtuse angles). The clods or blocks overlap only slightly and many vertical fractures are almost straight. There is less cohesion of soil material than in the moderately slow permeability class. Clods are more easily broken. Cleavage in most cases occurs along the faces of the nuciform aggregates, which are seldom fractured. Pores are larger and more numerous than in the soils of moderately slow permeability. Also, the color is usually light yellow and the degree of mottling is generally less, indicating a freer movement of water and air.

Moderately rapid permeability.--This rate of permeability is usually associated with soils ranging from moderately heavy to moderately light in texture. In general the soils have a *medium nuciform, coarse granular*, or *crumb* structure. The structural aggregates, in the main, are not so firmly developed as in the moderately permeable class. Vertical cleavage is nearly always along aggregate faces and follow more or less straight vertical or oblique lines, with only slight overlap of structural aggregates here and there. Pores in the aggregates are large and numerous. The color is moderately bright yellow, with or without mottlings.

Rapid permeability.--Permeability of this rate is usually associated with soils of light or moderately light texture and generally a crumb structure (sometimes ranging toward a single-grain condition). Pore space is large. Consistence usually ranges from only slightly plastic when wet to friable or crumbly when dry. Organic matter usually is moderate or low. Color is generally very bright and there are no mottlings, unless the water table is high.

Very rapid permeability.--Permeability of this rate is usually associated with sands, coarse sands, or gravelly soils. These generally have a single-grain structure. Consistence ranges from nonplastic when wet to incoherent when moist or dry. The color is bright, unless the water table is high.

Soil Structure[6]

Soil structure is a condition of the soil material in which the primary particles like sand, silt, and clay are arranged into aggregates. Aggregates differ in shape, in size, in stability, and in adhesion to one another.

Type of soil structure refers to shape of aggregates. Four main types are designated: Platy, prismatic, blocky, and granular (spheroidal). They are illustrated on *pages 26 and 27*.

Class of soil structure refers to size of aggregates. The size limits are given in *Table 1, page 25*.

Grade of soil structure refers to its relative distinctness; it is determined by a relative stability or durability of the aggregates and by the ease of their separation from one another. Grade of structure is the degree or distinctness of aggregation and expresses the differential between cohesion within aggregates and adhesion between aggregates. In field practice grade is evaluated mainly by noting the durability of the aggregates and the proportions between aggregated and unaggregated material that result when displaced or gently crushed. Grade of structure varies with moisture content of the soil and should be described at those which are relevant. If the moisture condition be unstated, descriptions of grade refer to a condition obtaining throughout the range dry to slightly moist. Terms for grade of structure are as follows:

Structureless. That condition in which there is no observable aggregation or no definite orderly arrangement of natural lines of weakness. *Massive* if coherent; *single grain* if noncoherent.

Weak. That degree of aggregation characterized by poorly formed indistinct aggregates that are barely observable in place. When disturbed, soil material that has this grade of structure breaks into a mixture of few entire aggregates, many broken aggregates, and much unaggregated material. If necessary for comparison this grade may be subdivided into very weak and moderately weak.

Moderate. That grade of structure characterized by well-formed distinct aggregates that are moderately durable and evident but not distinct in undisturbed soil. Soil material of this grade, when disturbed, breaks down into a mixture of many distinct entire aggregates, some broken aggregates, and little unaggregated material. Examples are loamy A horizons of typical Chestnut soils in the granular type and clayey B horizons of such Red and Yellow Podzolic soils as Boswell in the blocky type.

Strong. That grade of structure characterized by durable aggregates that are quite evident in undisplaced soil, that adhere to one another weakly, and that withstand displacement and become separated when the soil is disturbed. When removed from the profile, soil material of this grade of structure is very largely of entire aggregates and includes few broken aggregates and no

6 Adapted from article by Nikiforoff, C. C. Soil Science, 52: 193-212, 1941

unaggregated material. If necessary for comparison, the grade may be subdivided into moderately strong and very strong. Examples of strong grade of structure are the A horizons of typical Chernozem in the granular type and the B horizon of typical Solonetz in the prismatic type.

Many soils have compound structure, which requires description of the separate components.

Other conditions associated with structure are:

Clod. Irregular and rough in shape; rough edges; may be porous or dense. Usually is the result of cultivation. Range in size from small to very large.

Squamose. Scale-like aggregates arranged along horizontal plain; horizontal axes much longer than vertical; fragile to firm. Squamose structure differs from platy (laminar) structure in that the flattish scales are not as continuous and can be flaked off under proper field conditions.

Vesicular. Characterized by holes or cavities. The holes usually are about the size of the lead in a pencil but may be much smaller. The grade ranges from moderately firm to firm. May occur in almost any type of structure.

Single grain. Usually applies to sands. No cohesion between particles.

Amorphous. Without determinate shape; structureless. Usually applies to clays, ortstein layers or hardpan. In general dense or cemented.

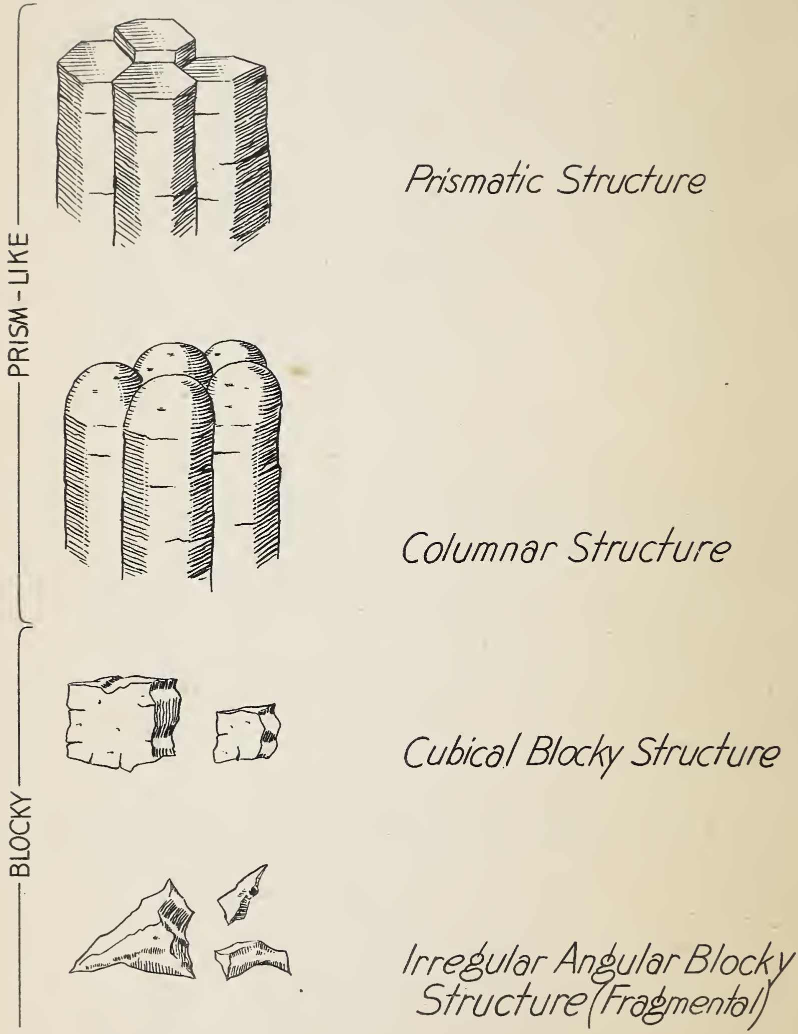
Pulverescent. Dust-like; applies to dust mulch.

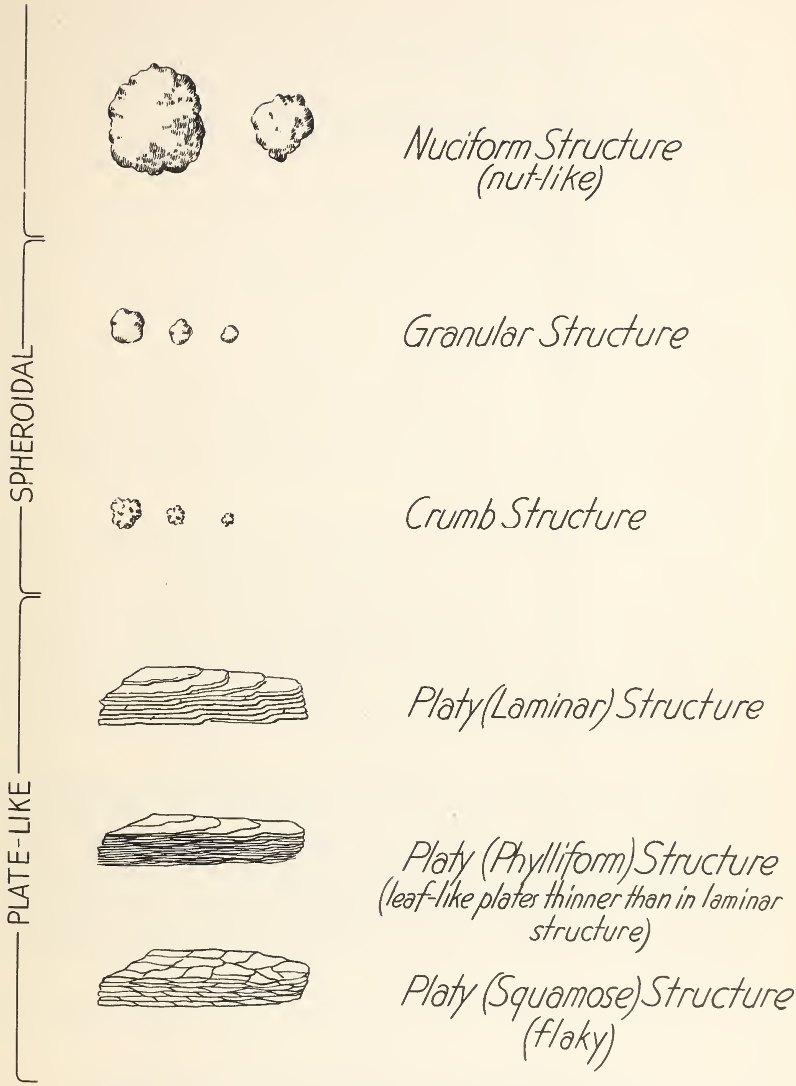
Arrangement of Soil Aggregates.--The permeability studies which were made in the North Central States indicate that in judging percolation rates in the field great reliance can be placed in indicators like type of structure and arrangement of the structure aggregates. Broadly speaking, soils with nuciform structure where the sub-rounded aggregates mesh along oblique lines and have little or no overlap are more permeable than soils where the aggregates are irregular angular blocky and have a horizontal overlap. But exception to this general rule occurs when irregular angular blocky aggregates overlap along oblique lines rather than horizontal. Also, a number of soils with irregular angular blocky structure may be placed into significantly different permeability classes on the basis of the amount of horizontal overlap. For example, when the horizontal overlap ranges from 15 to 25 percent the percolation rate is usually greater than when the aggregates overlap shingle fashion 40 to 50 percent. Therefore, in judging permeability in the field, consideration should be given not only to the type, class, and grade of structure, but to the arrangement of the aggregates one with the other. Seldom is it possible to estimate permeability on the basis of one indicator. The safest rule is to consider all observable indicators including type, class, and grade of structure, arrangement of structure aggregates, texture of soil, porosity, amount of dispersion, color, etc.

Table 1.--Types, Classes, and Grades of Soil Structure

Type	Class	mm.	Grade (Relative Distinctness)	Description
Platy Parallel horizontal axes; horizontal dimensions much greater than vertical.	Very thin Thin	< 1 1- 2	Very weak to weak Usually fragile	Paper-like plates; arranged like pages in a book (phylliform). Usually occur in the A horizon of virgin or fallow soils.
	Medium Thick Very thick	2- 5 5- 10 > 10	Weak to strong	May be scaly or flaky, Usually occur in subsoils or substratum--often vesicular. Sometimes plates are pitted but holes do not go entirely through. Squamose (flaky) is one kind of platy structure.
Prismatic Vertical cleavage; horizontal axes considerably less than vertical.	Very fine Fine Medium Coarse Very coarse	< 10 10- 20 20- 50 50-100 >100	Moderate to strong; In general can be handled roughly without destruction.	Prism-like aggregates, <u>flat topped</u>. Vertical faces usually well defined; surfaces vary from smooth to rough. The shape of the prisms when broken horizontally are dominantly roughly hexagonal but may be square, pentagonal, etc.
Columnar Vertical cleavage; horizontal axes considerably less than vertical.	Very fine Fine Medium Coarse Very coarse	< 10 10- 20 20- 50 50-100 >100	Moderate to strong; In general can be handled roughly without destruction.	Prism-like aggregates, <u>rounded caps.</u> Vertical faces usually well defined; surfaces range from smooth to rough. The shape of the prisms when broken horizontally are dominantly roughly hexagonal but may be square, pentagonal, etc.
Cubical blocky Horizontal and vertical cleavage planes.	Very fine Fine Medium Coarse Very coarse	< 5 5- 10 10- 20 20- 50 > 50	Moderate to very strong; can be freely handled without damage	Usually six-sided, ranging in shape from cube-like to irregular blocky. In general faces are rectangular and surfaces smooth to rough. The blocks either are stacked one above the other resembling a prism or overlap horizontally to various degrees. Vertical and horizontal axes are more or less equal in length.
Irregular angular blocky (fragmental)	Very fine Fine Medium Coarse Very coarse	< 5 5- 10 10- 20 20- 50 > 50	Moderate to very strong; usually moderately fragile to durable.	Irregular in shape with acute, sharp angles; horizontal axes usually longer than vertical. Faces vary from smooth to slightly rough. Fragments usually mesh shingle-fashion with 10 to 50% horizontal overlap; occasionally the overlap occurs along oblique rather than horizontal lines.
Nuciform (nutlike)	Fine Medium Coarse Very coarse	5- 10 10- 20 20- 50 > 50	Moderate to strong; usually moderately fragile to durable.	Sub-angular to sub-rounded with obtuse angles. Surfaces vary from smooth to rough. Some overlap of the aggregates occurs but in general cleavage is along vertical or oblique lines.
Granular	Very fine Fine Medium Coarse	< 1 1- 2 2- 5 5- 10	Moderate to strong; moderately durable to durable.	Somewhat rounded or shot-like; facets somewhat rough; usually there are no distinct facets or edges. Usually non-porous.
Crumb	Very fine Fine Medium Coarse	< 1 1- 2 2- 5 5- 10	Very weak to moderate; fragile to moderately durable.	Irregular rough shape; similar to a crumb of bread; usually quite porous.

SOIL STRUCTURAL FORMS




SPHEROIDAL
PLATE-LIKE
Nuciform Structure
(nut-like)
Granular Structure
Crumb Structure
Platy (Laminar) Structure
Platy (Phylliform) Structure
(leaf-like plates thinner than in laminar structure)
Platy (Squamose) Structure
(flaky)

Soil Consistence[7]

Soil consistence comprises the attributes of soil material that are expressed in the degree and kind of cohesion and adhesion or in the resistance to deformation or rupture. Every soil material has consistence irrespective of whether the mass be large or small, in a natural condition or greatly disturbed, aggregated or structureless. Although consistence and structure are interrelated, structure deals with the shape, size, and definition of natural aggregates that result from variations in the forces of attraction within a soil mass, whereas consistence deals with the strength and nature of such forces themselves.

Terms are provided for describing consistence at three standard moisture contents (dry, moist, and wet). Omission of statement of moisture condition when using any of the terms will denote the particular moisture content under which the term is defined. Thus *friable* used without statement of the moisture content specifies *friable when moist;* likewise, *hard* used alone means *hard when dry,* and *plastic* means *plastic when wet.* Any of the terms may, if appropriate, be used to describe consistence at some moisture content other than the standard condition under which the term is defined but when this is done statement of the moisture condition is essential. In relatively few instances it is necessary to describe consistence at all three standard moisture conditions. The consistence when moist commonly is the most significant and a description with this omitted can hardly be regarded as complete; the consistence when dry is generally useful but may be irrelevant in descriptions of soil materials that are never dry; the consistence when wet is unessential in the description of many soils but extremely important in some.

Although evaluation of consistence involves disturbance, unless otherwise stated, descriptions of consistence customarily refer to that of undisturbed material. In addition, descriptions of consistence under moist or wet conditions carry an implication that disturbance causes little modification of consistence or that the original consistence can be almost restored by pressing the material together. In those special cases, such as compacted layers, where such an implication is misleading, the consistence both before and after disturbance may require separate description. Likewise, compound consistences do occur, as for example in a loose mass of hard granules, and for complete description it is necessary to state consistence of the mass as a whole and of its parts.

A number of terms, including *brittle, crumbly, dense, plastic, fluffy, mealy, mellow, soft, spongy, stiff, tight, tough,* and several others, which have often been used in connection with descriptions of consistence, are not defined by this outline. As used in describing soils *fluffy* denotes a combination of loose to very friable consistence and low volume weight. All of these are good English words; some are indispensable for describing unusual conditions not covered by terms in the outline; and all have their place for use in nontechnical descriptions where some accuracy may need to be sacrificed to enhance readability. Whenever needed, terms for consistence not given in this outline should be employed with meanings as given in standard dictionaries.

I. Consistence when wet: To be determined at or slightly above field capacity.

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[7] From Committee Report on Soil Consistence, Division of Soil Survey, BPIS&AE, June 18, 1947.

A. *Stickiness:* The quality of adhesion to other objects. For field evaluation of stickiness, press soil material between thumb and finger and observe its tendency to adhere. Express degree as:

Nonsticky. After release of pressure, practically no soil material adheres to thumb or finger.

Slightly sticky. After pressure, soil material adheres to both thumb and finger but comes off one or the other rather cleanly. It is not appreciably stretched when the digits are separated.

Sticky. After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pulling free from either.

Very sticky. After pressure, soil material adheres strongly to both thumb and forefinger and is decidedly stretched when they are separated.

B. *Plasticity:* The ability to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. Determine plasticity by rolling soil material between thumb and finger and observing whether or not a wire can be formed. If beneficial in the particular description state the range of moisture content within which plasticity continues, as plastic when slightly moist or wetter, plastic when moderately moist or wetter, and plastic only when wet, or as plastic within a wide (medium or narrow) range of moisture content. Express degree of resistance to deformation at or slightly above field capacity as follows:

Nonplastic. No wire is formable.

Slightly plastic. Easily deformable.

Plastic. Plastic with moderate pressure required for deformation.

Very plastic. Plastic with much pressure required for deformation.

II. <u>Consistence when moist:</u> To be determined at a moisture content approximately midway between air dry and field capacity. At this moisture content most soil materials exhibit a form of consistence characterized by a tendency to break into smaller masses rather than into powder, some deformation prior to rupture, absence of brittleness, and ability of the material after disturbance to again cohere when pressed together. The resistance decreases with moisture content and accuracy of field descriptions of this consistence is limited by the accuracy of estimating moisture content. To evaluate this consistence, select and attempt to crush in the hand a mass that appears slightly moist.

Loose. Noncoherent.
Very friable. Soil material crushes under very gentle pressure but coheres when pressed together.
Friable. Soil material crushes under gentle to moderate pressure easily between thumb and forefinger, and coheres when pressed together.

Firm. Soil material crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.
Very firm. Soil material crushes under strong pressure; barely crushable between thumb and forefinger.
Extremely firm. Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

NOTE: The term *compact* denotes a combination of firm consistence and close packing or arrangement of particles and should be used only in this sense. It can be given degree by use of "very" and "extremely".

III. Consistence when dry: Air dry. The consistence of soil materials at this moisture content is characterized by rigidity, brittleness, maximum resistance to pressure, more or less tendency to crush to a powder or to fragments with rather sharp edges, and inability of crushed material to again cohere when pressed together. To evaluate, select an air dry mass and break in the hand.

Loose. Noncoherent.

Soft. Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

Slightly hard. Weakly resistant to pressure; easily broken between thumb and forefinger.

Hard. Moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

Very hard. Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

Extremely hard. Extremely resistant to pressure; cannot be broken in the hands.

IV. Cementation: Cementation of soil material refers to the brittle hard consistence caused by some cementing substance other than clay minerals, such as calcium carbonate, hydrates or salts of iron and aluminum, or silica. Typically the cementation is altered little if any by moistening, and the hardness and brittleness persists in the wet condition. Semi-reversible cements, which generally resist moistening but soften under prolonged wetting occur in some soils and give rise to soil layers having a cementation that is pronounced when dry but very weak when wet. Unless stated to the contrary, descriptions of cementation imply that the condition is altered little if any by wetting; if the cementation is greatly altered by moistening, it should be so stated. Cementation may be either continuous or discontinuous within a given layer.

Weakly cemented. Cemented mass is brittle and hard but can be broken in the hands.
Strongly cemented. Cemented mass is brittle and harder than can be broken in the hand but is easily broken with a hammer.
Indurated. Very strongly cemented; brittle, does not soften under prolonged wetting, and is so extremely hard that for breakage a sharp blow with a hammer is required; hammer generally rings as a result of the blow.

Systems for Coding Soil Characteristics

A region-wide or nation-wide system for coding soil characteristics will be helpful for technicians who work with more than one legend. It aids in quick recognition of the distinguishing characteristics of soil mapping units. One such system is being used in the legends for the Southwestern Region (Region 6) of the Soil Conservation Service. Soil symbols used in these legends show the major soil characteristics of texture, permeability of subsoil and of substratum, and effective depth. Similar schemes have been tried in several other regions, some of them involving symbols for use directly on maps, others a coding system for quick identification of mapping symbols.

If a coding system is used, significant soil characteristics, applicable over an entire region, should be selected and suitable symbols assigned. Symbols showing ranges of several significant characteristics are given on the following pages. If additional subdivisions of any range of characteristics are needed, or if broader ranges will suffice, the symbols should be assigned in the following order: Low numbers to indicate deep soils, heavy textures, and slow permeabilities rather than the reverse.

The four characteristics of effective depth, surface texture, permeability of subsoil, and permeability of substratum, will be needed to characterize a great many soils. One or both of the permeability designations should usually be omitted, however, for those soils that are shallow or very shallow over rock. The order of expression given below, starting with effective depth, is suggested unless some other order is already established or is clearly more satisfactory.

Table 2.--Characteristics that may be used for coding soils.

Symbol[8]	Effective Depth	Texture	Permeability of Subsoil	Permeability of Substratum
1	Very deep (if used)	Very heavy	Very slow	Very slow
2	Deep	Heavy	Slow	Slow
3	Moderately deep	Moderately heavy	Moderately slow	Moderately slow
4	Shallow	Medium	Moderate	Moderate
5	Very shallow	Moderately light	Moderately rapid	Moderately rapid
6	-----	Light	Rapid	Rapid
7	-----	Very light	Very rapid	Very rapid

[8] Stony, gravelly, or ledgy soils may be shown by placing the following symbols in front of the proper texture numeral; S - stony; V - very stony; L - rock ledges; G - gravelly; and R - very gravelly.

Underlying material in some soils is a significant factor which should be expressed with code symbols. The symbol for underlying material should follow the first four digits; or if the soil is shallow or very shallow, it may be an adequate substitute for the fourth or for the third and fourth digits.

The following list of symbols is recommended for use as far as it can be applied:

A - Acid igneous
B - Basic igneous
C - Chert or flint
D - Loess or fine-grained aeolian material
E - Shale
F - Sandstone
G - Glacial material
H - Gypsum
I - Schist
J - Quartzite
K - Slate
L - Limestone
M - Muck
N - Marl or chalk
P - Peat
Q - Sand
R - Caliche
S - Coastal plain material not consolidated
T - Old alluvial material, terrace, and outwash
U - Colluvial material
V - Lacustrine material
X - Recent alluvial material

Additional symbols will be needed occasionally to characterize further the type of material or size of grains. Glacial material derived from shale or mixed materials should be designated by combinations of symbols such as GE (glaciated shale), GLE (glaciated limestone and shale), or GFE (glaciated sandstone and shale).

A capital letter O, as LO (shattered limestone), indicates shattered rock.

Numerals should be selected for use with the capital letters to indicate specific types of material. Examples are E1 for clay shales, F1 for siltstone, or Q2 for greensand (glauconitic sand). Use of such qualifying numerals on a national basis will not be suggested at this time.

Coastal plain, old alluvial (terrace), colluvial, lacustrine, and recent alluvial materials may be subdivided according to texture if that information is likely to prove helpful and is not conveyed adequately by the symbol expressing permeability of substratum. For this purpose the numerals given for textural groups should be used. For example, use S2 for heavy coastal plain material; T7 for very light textured old alluvium.

Additional symbols should be used for coding the following characteristics if needed: Thickness of surface soil, thickness of subsoil, available moisture capacity, reaction, natural soil drainage, inherent fertility, and organic content. Each symbol consists of two parts, a small letter to show the characteristic and a numeral to show the modifying prefix or suffix. For example, m1 shows very high available moisture capacity, and h3 low organic content. These soil characteristics should be coded only if they are needed to differentiate soil mapping units. Those that are used should be listed in the order given in the tabulation on the following page.

Table 3.--Other soil characteristics that may be used in coding soils

Numeral	Thickness of surface a	Thickness of subsoil b	Available moisture capacity m	Reaction p	Natural aoil drainage d	Inherent fertility n	Organic content h
1	Thin	Thin	Very high	-----	Well	High	High
2	Moderately thick	Moderately thick	High	Acid	Moderately well	Moderate	Medium
3	Thick	Thick	Moderate	----	Imperfect (somewhat poor)	Low	Low
4	Very thick	Very thick	Low	Neutral	Poor	Very low	-----
5	-----	-----	Very low	-----	Very poor	-----	-----
6	-----	-----	-----	Alkaline	-----	-----	-----

Examplea of this coding system then would be: 2455, a deep, medium-textured soil that has moderately rapid permeability in subsoil and substratum; 53L, a very shallow, moderately heavy soil over limestone; and 2656n3, a deep sandy soil that has low inherent fertility. It is recommended that the code designations be kept as short as possible, and that the characteristics indicated here by small letters be specified only to indicate outstanding soil characteristics.

Code symbols may be shown as part of the table of soil characteristics mentioned on *page 14* and illustrated by *table 6* in the appendix. The table of soil characteristics should be prepared, however, whether a coding system is adopted or not.

Table 4.--Summary of terms used to describe principal

Effective depth	Texture of surface	Permeability (inches per hour)		Thickness	
		Subsoil	Substratum	Surface	Subsoil
Very deep 60" or more	Very heavy (heavy clay; 60% or more 2-micron clay)	Very slow (less than 0.05)	Very slow (less than 0.05)	Thin (0 - 6")	Thin (0 - 6")
Deep (36-60")	Heavy (clay, silty clay, sandy clay)	Slow (0.05-0.20)	Slow (0.05-0.20)	Moderately thick (6 - 12")	Moderately thick (6 - 12")
Moderately deep (20-36")	Moderately heavy (silty clay loam, clay loam, sandy clay loam)	Moderately slow (0.20-0.80)	Moderately slow (0.20-0.80)	Thick (12 - 18")	Thick (12 - 18")
Shallow (10-20")	Medium (silt loam, loam, very fine sandy loam)	Moderate (0.80-2.50)	Moderate (0.80-2.50)	Very thick (18 - 36")	Very thick (18 - 36")
Very shallow (0-10")	Moderately light (sandy loam, fine sandy loam)	Moderately rapid (2.50-5.00)	Moderately rapid (2.50-5.00)	---	---
---	Light (loamy fine sand, loamy sand)	Rapid (5.00-10.00)	Rapid (5.00-10.00)	---	---
---	Very light (sand, coarse sand)	Very rapid (10.00 or more)	Very rapid (10.00 or more)	---	---

*If <u>very deep</u> is not needed, use <u>deep</u> to designate 36" or more.

soil characteristics in soil conservation surveys.

Available moisture capacity (inches of water per 60" of soil depth)	Reaction	Natural soil drainage	Inherent fertility	Organic content
Very high (12" or more)	---	Well drained (well oxidized and free from mottling in surface and subsoil)	High	High
High (9 - 12")	Acid (6.5 pH or less)	Moderately well drained (well oxidized and free from mottling except lower part of subsoil)	Moderate	Medium
Moderate (6 - 9")	---	Imperfectly drained or somewhat poorly drained (well oxidized surface; subsoil mottled)	Low	Low
Low (3 - 6")	Neutral (6.6 - 7.3 pH)	Poorly drained (gray colors; mottling in surface and subsoil)	Very low	---
Very low (less than 3")	---	Very poorly drained (dark surface soil and gray or mottled subsoil)	---	---
---	Alkaline (7.4 pH or more)	-----	---	---
---	---	-----	---	---

Table 5.--Summary of terms used to describe

Slope	Erosion	Wetness
Nearly level	No apparent or slight (+, 0, 1, 17, P)	Slightly wet (Growth of crops slightly affected or planting dates delayed for brief periods)
Gently sloping	Moderate (17, 2, 27, 27, 17V, 27V, R)	Moderately wet (Growth of crops moderately affected, or planting dates delayed by a week or so)
Moderately sloping	Severe (28, 3, 37, 37, 37V, S)	Very wet (Growth of crops seriously affected or planting delayed as much as a month or more)
Strongly sloping	Very severe (38, 4, 48, 5, T)	Extremely wet (Swamp, marsh; too wet for cultivated crops or improved pasture)
Steep	Very severely gullied land (38, 38V, 48, 48V, 9)	----------
Very steep	----------	----------

associated land features in soil conservation surveys.

Salinity	Frequency of Overflow
Slight salinity (Crop yields slightly affected or range of crops slightly limited)	Occasional overflows or overflows of short duration (Crops occasionally damaged or planting dates delayed)
Moderate salinity (Crop yields moderately affected or range of crops moderately limited)	Frequent damaging overflows or overflows of long duration (Crops frequently damaged, or range of crops limited)
Severe salinity (Crop yields seriously affected or range of crops severely limited)	Very frequent overflows or overflows of very long duration (Not feasible for cultivated crops)
Very severe salinity (Growth of useful vegetation prohibited except some salt-tolerant forms)	----------
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Table 6.--Principal characteristics of several soil

Field mapping symbol	Descriptive titles	Effective depth	Texture of surface	Permeability		Thickness surface
				Subsoil	Substratum	
9	Dark-colored, deep, med. textured soils with mod. rapidly permeable subsoils and substrata	Deep	Medium	Moderately rapid	Moderately rapid	-----
15	Mod. dark-colored, shallow to claypan, very slowly permeable, med.-textured soils	Shallow	Medium	Very slow	Very slow	-----
10	Light-colored, shallow to claypan, very slowly permeable, medium-textured soils	Shallow	Medium	Very slow	Very slow	-----
183	Light-colored, moderately deep to rock, medium-textured soils with mod. permeable subsoils	Moderately deep	Medium	Moderate	-----	-----
1110	Deep, well drained, medium-textured, moderately slowly permeable, high lime soils	Deep	Medium	Moderately slow	Moderately slow	-----
9413	Deep, well drained, mod. light-textured soils with mod. permeable subsoils and rapidly permeable substrata	Deep	Moderately light	Moderate	Rapid	-----
18	Shallow to gravel and sand, dark-colored, med. textured soils with rapidly permeable subsoils and very rapidly permeable substrata	Shallow	Medium	Rapid	Very rapid	-----
2M	Deep, light-colored, medium-textured, highly productive soils with good drainage	Deep	Medium	Moderate	Moderate	-----
6M	Light-colored, medium-textured soils, shallow to bedrock	Shallow	Medium	Moderate	-----	-----
3331	Deep, med.-textured soils with mod. thick surface layers and mod. permeable subsoils and substrata	Deep	Medium	Moderate	Moderate	Moderately thick
3231	Deep, med.-textured soils with thin surface layers, slowly permeable subsoils and moderately permeable substrata	Deep	Medium	Slow	Moderate	Thin

mapping units defined for soil conservation surveys.,

Underlying or parent material	Available moisture capacity	Reaction	Natural soil drainage	Inherent fertility	Organic content	Dominant soil type or types
Loess	High	V. slightly acid to mildly alkaline	Well	High	High	Marshall silt loam and similar soils
Loess	Low	Acid	Poor	Medium	Medium	Putnam silt loam and similar soils
Loess	Low	Acid	Poor	Low	Low	Marion silt loam and similar soils
Limestone	Low	Acid surf. and subsoil, calc. substratum	Well	Medium	Low	Dubuque silt loam and similar soils
Glacial till (limestone)	High	Acid to neutral, 20" to calc. matl.	Well	High	Medium	Honeoye silt loam and similar soils
Coastal Plain (sand, gravel, and silt)	Low	Acid	Well	Medium	Low	Sassafras sandy loam and similar soils
Lacustrine (gravel and sand)	Very low	Moderately acid; shallow to lime	Well	Low	Medium	Sioux loam and similar soils
Loess	High	Neutral	Well	High	Medium	Palouse silt loam and similar soils
Granites, micaceous schists, and gneiss	Low	Acid	Well	Low	Medium	Moscow loam and similar soils
Loess or wind modified material	High	Neutral	----	High	Medium	Keith silt loam
Loess or silty material blown from soft shale or sandstone	High	Neutral	-----	High	Medium	Weld loam